Question 2: Antenna system analysis (10 points)

Consider the setup shown in Figure 3 and the table provided below. Both transmitter and receiver use identical antennas with directivity and radiation efficiency as provided in the table. Unless indicated otherwise, all devices are perfectly matched to each other, antennas are linearly polarized, antennas are oriented such that their polarizations align, and you may assume a direct line-of-sight between the antennas.

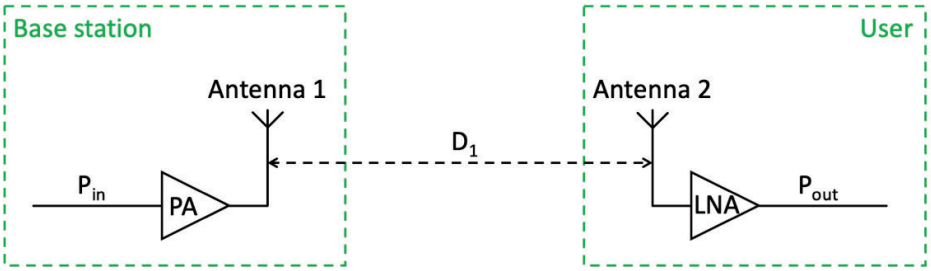

Figure 3: Setup for Question 2a)-2c).

Centre frequency f_c	3 GHz
Power gain of the base station's power amplifier (PA), G_{PA}	15 dB
Power gain of the user's low-noise amplifier (LNA), G_{LNA}	18 dB
Antenna 1 gain (base station), $G_{ant,1}$	21 dBi
Antenna 2 gain (user), $G_{ant,2}$	0 dBi
Distance base station to user, D_1	2 km

a) Calculate the Equivalent Isotropically Radiated Power (EIRP) of the base station when P_{in} = 10 dBm at the base station's PA input.
b) It is now desired to obtain P_{out} = -65 dBm at the output of the user's LNA. Calculate the required P_{in} at the base-station to achieve this. Provide your answer both in [dBm] and in [mW].
c) Suppose antenna 2 has a total efficiency of 10%. What is its directivity $D_{ant,2}$ in dBi?

Unfortunately for the user, a source of interference has popped up at the same frequency, as shown in Figure 4, with the properties given in the table below.

Interferer output power P_{int}	12 dBm
Antenna 3 gain (interferer), $G_{ant,3}$	5 dBi
Distance interferer to user, D_2	1 km

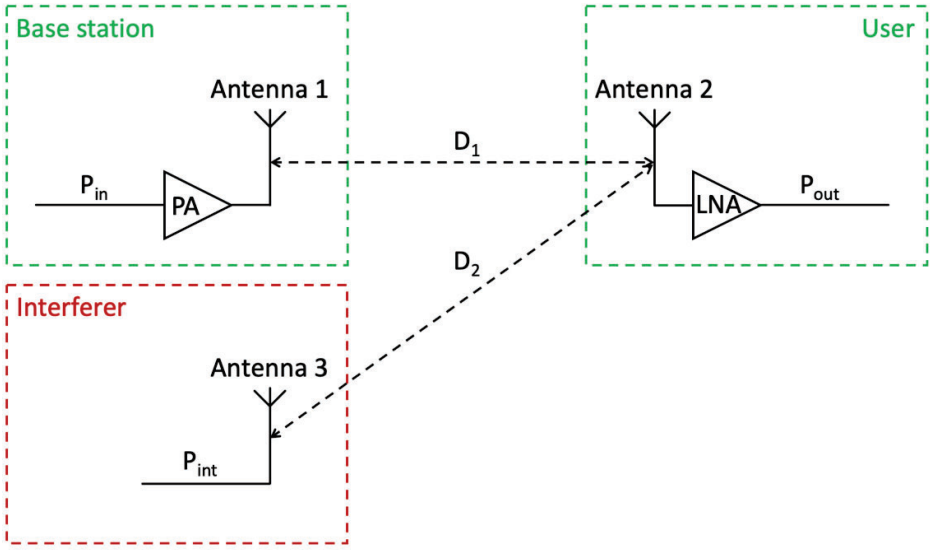

Figure 4: Setup for Question 2d)-e).

d) The interferer is located at the edge of the half-power beam width (HPBW) of the user. What is the minimum power due to the interfering signal (only!) at the output of the user's LNA?

e) The user, who is in an environment with a lot of buildings, notices large differences in the power received from both the base station and the interferer when the antenna is moved only slightly. What would be the probable cause for this?